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NESTING HABITAT CHARACTERISTICS, BREEDING BIOLOGY, AND CONSERVATION OF THE MALABAR GREY HORNBILL (*Ocyceros griseus*) IN ANAMALAIS, SOUTHERN WESTERN GHATS, INDIA.

Abstract:

I studied the nesting habitat and breeding biology of the frugivorous Malabar Grey Hornbill (Aves: Bucerotidae), a secondary cavity nesting endemic, restricted to the moist deciduous and wet evergreen forests of the Western Ghats, India. The study was carried out for a period of six months, from December 1993 to May 1994, in Indira Gandhi Wildlife Sanctuary, Tamil Nadu state. Nine cavity-related, four centre-tree-related and six vegetation attributes were evaluated for nest characteristics by comparing nest-tree-centred circular plots (0.07 ha. each) with an equal number of random plots. The hornbills used thirteen species of trees for nesting, of which *Alseodaphne semecarpifolia* contained seven nests. Twenty-six nests were in live trees. They were commonly found in open, tall, mature, wet evergreen forest stands with dense undergrowth. Nest trees had a significantly greater diameter at breast height (Mann-Whitney U-test, $U = 136$, $n = 27$, $p = 0.0001$) and height of the lowest limb (Mann-Whitney U-test, $U = 163$, $p = 0.0005$) than random trees. The density of trees in the 60-74 cm DBH class was higher in the nest plots than in the random plots (Mann-Whitney U-test, $U = 177.5$, $p = 0.0005$). A significant proportion (52%) of nests were on large trees, and nest tree attributes seem to influence nest-site selection. The breeding biology of the species was studied by intensive observations on one nest and monitoring middens of nine other nests. The mean nesting period was estimated to be 85 days (SE = 1.09). During the nesting period, hornbills fed on nine species of sugar-rich fruits, ten species of lipid-rich fruits, and 14 species of animal food. The frequency of sugar- and lipid-rich fruits in the diets of hornbills was significantly higher in the pre-hatching phase (Mann-Whitney U-Test, $U = 24$, $n_1 = 16$, $n_2 = 12$, $p = 0.008$ & $U = 36$, $p = 0.0012$ respectively), while there was no difference in their biomass between the two phases (Mann-Whitney U-test, $U = 66$, $p = 0.16$ & $U = 65$, $p = 0.15$ respectively). Both frequency (Mann-Whitney U-Test, $U = 41$, $p = 0.01$) and biomass (Invertebrate: $U = 53.5$, $p = 0.05$; Vertebrate: $U = 64$, $p = 0.01$) of animal food was higher in the post-hatching than in the pre-hatching phase. Since hornbills rely heavily on mature forests to meet their nesting and feeding requirements, the need to preserve the integrity of these habitats is emphasised in this study.

Introduction

The Malabar Grey Hornbill (*Ocyrceros griseus*) is the smallest of all the hornbill species of the Indo-Malayan region. These hornbills are forest-dwelling arboreal birds. They are long lived, and have a distinct and relatively long nesting period. They are monogamous (Kemp 1978, Ali & Ripley 1987). Like most other monogamous birds with altricial young, these birds also exhibit biparental care (Clutton-Brock 1991). As with all hornbills, during nesting, the female incarcerates itself in the nest cavity incubating and protecting the eggs, while the male provisions the inmates throughout the nesting period. The Malabar Grey Hornbill is about 59 cm in length and weighs about 300 gm (Kemp 1978, Ali and Ripley 1987). They are sexually dimorphic in their bill and eye colours. Like all the members of its family, it is a secondary cavity nester, largely using traditional nesting cavities. Cavities are an important resource in forests for many birds and mammals which use them for nesting, roosting, and escape from predators (Conner 1976, Kemp 1976, Cody 1985, Martin 1988).

The Malabar Grey Hornbill is distributed from Khandala (74°E and 18°N) in the north to Travancore (77°E and 8°N) in the south, along the Western Ghats. It is restricted to the moist deciduous and wet evergreen forests and is believed to be common in most parts of its range (Ali & Ripley 1987). The only information available are in the form of natural history and anecdotal notes (Bingham 1879, Hall 1918, Lowther 1942, Abdulali 1942). The Malabar Grey Hornbill, along with the sympatric Great Pied Hornbill (*Buceros bicornis*), are large, wide-ranging frugivores in the region. They, as keystone mutualists play an important role in the dispersal of certain large-seeded rainforest tree species (Lauraceae, Myristicaceae; McKay 1975, Gilbert 1980). They can also be considered as indicators of the habitat due to their specialised food and nesting habitat requirements (Gilbert 1980, Leighton & Leighton 1983). Their habitats have been extensively reduced in the recent years and what remains are fragmented patches (Chattopadhyay = 1985). This study was carried out as it is imperative to know the habitat requirements of the species for its conservation and long-term survival.

Field work was carried out for a period of six months, from December 1993 to May 1994, coinciding with the breeding season of the Malabar Grey Hornbill (Ali & Ripley 1987). This study was conducted in Indira Gandhi Wildlife Sanctuary (76° 49' to 77° 21' E and 10° 13' to 10° 33' N) which is spread over an area of 987 km² in the mountainous terrain of the Anamalai Hills of the southern Western Ghats in the state of Tamil Nadu. Intensive study was restricted to the nests in Karian Shola (5.1 km²), a tropical evergreen forest classified as the *Hopea parviflora* - *Mesua ferrea* forest type (Champion & Seth 1968), at an altitude of about 750 m. It is surrounded by bamboo and open deciduous forests. Attempts were made to describe 1) the nesting habitat requirements 2) the various phases of the nesting period and 3) the feeding habits of the nesting birds.

Methods

Malabar Grey Hornbill nests were located by using the knowledge of a tribal guide who was aware of the traditional nests, following the movement of parent

birds, and checking for middens (i.e., the pile of seeds and faecal matter at the base of the nest tree).

Nesting habitat characterization:

The habitat quantification methods followed James and Shugart (1970) with certain modifications to suit the tropical evergreen forest conditions (Table 1). Nest-tree-centred circular plots (15 m radius) were compared with circular random plots 75 m from the nest-tree to determine the habitat or nest-tree factors that are likely to affect the choice of nesting habitat by the Malabar Grey Hornbill. The trees of DBH classes with the least variability are pooled into three major size classes - medium (30-45 cm), large (45-75 cm) and very large (>75 cm). Five belt transects of 200 m X 10 m (total area of 1 ha.) were laid at random to determine the relative abundance of a few important nest tree species.

Breeding biology:

Ten nests were monitored to study the breeding biology of the species. Of these, one nest was intensively observed for approximately 6-hour periods on every alternate day throughout the nesting period. During these observations, I gathered information on the quality and quantity of food delivered by the male to the incarcerated female and the young. The observations were made between 0700 hrs and 1300 hrs from a ground hide through a 7x50 binoculars or a 20x50 spotting scope. For each visit by the male, the number and type of food items delivered, the duration of the visit (to the nearest 5 seconds), and the total number of visitations to the nest during this period were recorded. At the end of the day's observation, the seeds and other faecal remains in the midden were examined, identified and recorded. The midden of nine nests were monitored to supplement information on the diet of the nesting birds.

The food was broadly classified as plant and animal food. Most food items were identified on the field; Plant food that could not be assigned to species were identified from herbarium specimen with the help of local floras (Gamble 1967). The plant food was categorized as a) Figs, b) Sugar-rich non-fig and c) Lipid-rich fruits, based on McKey (1975) and Snow (1981). The food items in each category were standardized based on the size by equating them to the largest fruit/animal in that category. This was used as an index of biomass for each category.

Analyses: I used non-parametric Mann-Whitney U-test to determine the nesting habitat characteristics of the Malabar Grey Hornbill, using the standard SPSS software package (Norusis 1990) at a significance of $p < 0.01$. The frequency (in numbers/hour and as the biomass/hour) of each food type delivered was calculated. Differences in the quantity and quality of each food type delivered between the pre- and post-hatching phases were tested for statistical significance ($p < 0.01$) using non-parametric Mann-Whitney U Test (Seigel & Castellan 1988).

Results:

Nesting habitat characteristics:

Most of the nests were in open, tall (average canopy height = 23.9 ± 0.8 m), evergreen forest with dense undergrowth. Analysis (Mann-Whitney U-test) of six

habitat variables of 27 nest-site plots and an equal number of random plots, showed that the number of trees of the 60-74 cm DBH class were significantly more in the nest plots than in the random plots (Mann-Whitney U-test, $U = 177.5$, n_1 & $n_2 = 27$, $p = 0.0005$). However, the frequency distributions of trees of the three size classes in the nest-site and random plots were similar to each other.

Nest-tree characteristics:

The diameter at breast height (Mann-Whitney U-test, $x = 75.3 \pm 5.3$ cm, $U = 136$, $p = 0.0001$) and the height of the lowest branch (Mann-Whitney U-test, $x = 15.7 \pm 0.9$ m, $U = 163$, $p = 0.0005$) were greater in the nest trees than in the random trees. The hornbills were nesting in trees of large diameter. Twenty two (81%) of the 27 nests were on emergent trees. The mean emergence of trees above the canopy in the nest-site plots was 3.8 m (SE = 1 m), about 3.5 m higher than in the random plots. The DBH of the nest tree and its height were correlated ($r = 0.438$, $p = 0.02$) and the latter was in turn correlated with the height of the lowest limb ($r = 0.626$, $p < 0.001$). The above variables reflect the Malabar Grey Hornbill's choice of large trees for nesting. Trees of the large and very large size classes were commonly used. A higher proportion of nests occurred in large (45-75 cm DBH) and very large trees (<75 cm DBH; 52% & 41% respectively), although only 21.4% and 9.6% of the trees were of these classes. Only two (7%) nests were in medium sized trees (30-45 cm DBH).

Seven of the 27 nests were in *Alseodaphne semecarpifolia* trees. The three other species of trees that had the most number of nests were *Hopea parviflora*, *Aglaia roxburghiana* and *Artocarpus lakoocha* (4 each). The relative abundances of these and other nest trees is given in table 2. A study of the nest tree species choice could yield valuable information for the conservation of suitable nest trees.

Nest cavity characteristics:

The nest cavities were located at an average height of 18 m, and the average diameter of the cavity entrance was about 8 cm. The mean of diameter at nest height (DNH) was estimated to be 42 cm ($N = 27$). The cavity entrance was circular in 25 of the 27 nests and oval in the other two. All cavities, except one, were in live trees. Twenty one (78%) of the nest-cavities utilized were formed due to heart rot where branches had broken off, while the others were those excavated by primary hole nesters. Sixteen (59%) of the nests were on the main trunk and the rest on branches. A majority (59%) of the nest cavities were located at a height of 9-18 m, the middle third of the tree. A higher proportion (44%) of active nests were oriented in the north-east direction (Fig. 2).

Breeding biology:

The nesting period (i.e., the period from the time of incarceration of the female to the fledging of the chicks) in the focal nest lasted for a period of 86 days (from 18 Feb 1994 to 15 May 1994). The young hatched about 40 days after the incarceration of the female. The post-hatching period lasted about 46 days. The female and the young broke out of the nest simultaneously. Only one chick seemed to have fledged. The mean duration of incarceration is estimated to be 85 days ($N=9$; SE = 1.09).

The focal nest was observed for a total of 161 hours and 45 minutes. Throughout the nesting period, the male diligently provisioned the incarcerated

female and later, the young also. A total of 2397 food items which comprised of fruits, insects, scorpions, etc., were brought to the nest by the male. All items were regurgitated. Nineteen species of fruits, 5 species of vertebrates, and at least 9 groups of invertebrates were delivered at the nest (Appendix). The number of food items delivered peaked during the incubation/pre-hatching phase, and declined thereafter. It was the least just before the fledging of the young. However, it does not signify difference in the biomass or the quality of the food taken by the inmates. A greater number of small fruits (61 %) were delivered during the pre-hatching phase, and resulted in the male spending a significantly higher time at the nest (Mann-Whitney U-Test, $U = 38$, $p = 0.007$), though the visitation rate did not differ significantly between the two phases (Mann-Whitney U-Test, $U = 85$, $p = 0.7$; Fig. 3). In the post-hatching phase a larger proportion of large fruits (4 %), most of which were lipid-rich, invertebrates (8 %) and vertebrates were delivered, and less time spent at nest per visit. The frequency of non-fig sugar-rich (Mann-Whitney U-Test, $U = 24$, $n_1 = 16$, $n_2 = 12$, $p = 0.008$) and lipid-rich fruits (Mann-Whitney U-Test, $U = 36$, $p = 0.0012$) delivered (per hour) was significantly higher in the pre-hatching than in the post-hatching phase. But there was no difference in their biomass between the two phases (Mann-Whitney U-test, $U = 66$, $p = 0.16$ & $U = 65$, $p = 0.15$ respectively). Figs occurred in the diet consistently throughout the nesting period. Both frequency (Mann-Whitney U-Test, $U = 41$, $p = 0.01$) and biomass (Invertebrate: $U = 53.5$, $p = 0.05$; Vertebrate: $U = 64$, $p = 0.01$) of animal-food in the diet was greater in the post-hatching than the pre-hatching phase.

Discussion

Nest-site preference:

To recapitulate, the nests of the Malabar Grey Hornbill were found in open, tall evergreen forest along forest trails, edges, and in the interior areas, all having dense undergrowth. The Malabar Grey Hornbill prefers trees of a higher DBH (a mean of 75 cm vs 46 cm) and height of the first branch (16 m vs 11 m), and habitat with a higher number of trees of large DBH classes (>60 cm). These reflect the size and age of the nest tree. This implies a choice of forest stands with old, mature trees. Comparison between the nesting habitat preference of the Great Pied Hornbill (Kannan 1994) and Malabar Grey Hornbill shows that there is little overlap between the two sympatric hornbills in the study area. Similar studies in Thailand, having four sympatric hornbills have shown that the larger hornbills nest in trees of a greater DBH (110 cm), while the smaller hornbills nest in trees of mean DBH 75 cm (Poonswad *et al.* 1988, Poonswad & Tsuji 1989).

Relatively more nests were found in trees of large DBH classes, particularly in the 60-89 cm DBH range. This cannot be taken to indicate the preference of the hornbills as it may simply reflect the greater availability of suitable cavities in larger trees (Mudappa & Kannan *in press*). There could possibly be a preference for nesting-tree species. Nest tree species preference of *Eugenia* and *Dipterocarp* spp. has been reported from studies in Thailand (Poonswad 1994). Nest-tree and nest-cavity factors may be the most important primary factors influencing the nesting habitat choice (Kinnaird & O'Brien 1993). Orientation of the nest-cavities in the north-east direction may indicate the formation of cavities in that aspect

rather than the choice of the hornbills. Predation of adult Malabar Grey Hornbills by animals other than man is very rare. Even during the nesting period, predation is low and this can be attributed to the sealed nest cavity entrance, and the presence of the female itself, whose heavily armoured large bill can protect the nest from intruders.

Nesting-period:

Cavity nesting birds have a relatively long nesting period (Cody 1985), it being about 85 days in the Malabar Grey Hornbill. While the female is incarcerated in the nest cavity incubating the clutch, the male provisions the inmates. The nesting cycle of the Malabar Grey Hornbill in the area seems to be synchronised with the peak in food availability (see Kannan 1994), and the onset of monsoon. A study of the sympatric Great Pied Hornbill in the same area found that they also nest during the same period (Kannan 1994). Studies in Thailand (Poonswad *et al.* 1988) have found the nesting to commence and terminate later than was found in this region, the late monsoon probably being the cause.

During this study, there were well-defined periods when particular foods were delivered more than others at the nest (Mudappa *in prep.*). All through the nesting period, at least one species of lipid-rich fruit was being fed to the inmates in abundance. Lipid-rich fruits are highly seasonal and synchronous in their fruiting (McKey 1975, Snow 1981, Leighton & Leighton 1983, Kannan 1994) and this episode coincides with the nesting period of the hornbills and forms a major component of its diet. The significantly higher biomass of animal food in the post-hatching phase is likely to meet the nutritional requirement of the young. The kind of food delivered, determined and influenced the visitation rate and the time spent at nest by the male. The time spent at nest decreased towards the end of the nesting cycle. There was a drastic fall in the number of visits the last few days of the nesting period. Welty (1982) proposes that the steady decline in feeding frequency may be a naturally evolved strategy of the parent to encourage the nearly fledged young to leave the nest.

Conclusion:

Mature forest stands with optimal nesting and foraging habitats are essential requirements for species like the hornbills. They are a group of large, wide-ranging birds, with specialized nesting and feeding habits. They are vulnerable to loss and destruction of their habitats. Conservation of hornbills then assumes a greater importance in preserving their habitat. Western Ghats, which once had large, contiguous stretches of forests are now reduced to fragments mainly due to conversion to plantations or other developmental activities. Large, live trees, of DBH > 60 cm are important to the Malabar Grey Hornbill. Selective logging of large trees for timber and the practice of "improvement felling" (*i.e.*, removal of snags or trees with cavities, strangler figs, etc.) may limit the availability of suitable nest sites and foraging habitats for these birds and must be stopped where ever it exists. However, this practice does not exist in my study-site or in other parts of southern Western Ghats any more. Where logging is authorised by the state Forest Department, at least large fruiting trees and trees with existing nest cavities must be spared as these birds use

ditional nest sites. These trees are essential for the Malabar Grey Hornbill as potential nesting-sites. Large fruiting trees have been shown to be an important component of hornbill habitat (Kannan 1994).

Hornbills are a rare and important group of large, frugivorous, forest and canopy birds in the Old World Tropics (McKey 1975, Kemp 1978). As seed dispersers of many rare rainforest trees, they play an important role as "mobile links" and "key-stone" species in the food-web structure and conservation of these rainforests (Gilbert 1980, Leighton & Leighton 1983, Kannan 1994). These endemic, specialist frugivores of the rainforest of the Western Ghats play an important role in the dynamics of the moist evergreen forests they inhabit. They persist on an array of diverse, locally rare, tree species (eg. members of Lauraceae). The fruiting of species bearing lipid-rich fruits is usually highly seasonal and synchronous (Snow 1981, Leighton & Leighton 1983, Kinnaird 1993, Kannan 1994), while the sugar-rich fruits are available all through the year. It has been found that community fruiting patterns are largely shaped by the trees producing lipid-rich fruits like Lauraceae, Annonaceae, and others as they form a majority of species in the study area (Kannan 1994). It seems likely that it is the quality rather than the quantity of food, and suitable nesting habitat that determine their survival (Kannan 1994, Mudappa 1994). Thus, coincidence of the fruiting of the lipid-rich species with the nesting season of the hornbills, probably has an evolutionary significance. These and other large-seeded tree species are dependent on hornbills for the dispersal of its seeds. The hornbills in turn are behaviourally and physiologically adapted to disperse these large-seeded fruits (Snow 1971, McKey 1975, Wheelwright 1985). Further quantitative observation on frugivory is wanted. These large, specialised frugivores, are not only important primary dispersers of some rare and important rain forest tree species (McKey 1975, Leighton 1982, Kannan 1994), but their nest midden, being a rich deposit of seeds, is a source of resource for secondary dispersers and seed predators as well. They are a wide-ranging species which require large patches of forests with adequate fruiting and nesting trees. Therefore, it is imperative to protect what is left of their habitat.

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* - Not Seen in Original.

Table 1: Methods used to Quantify the Nesting Habitat of the
 Malabar Grey Hornbill (after James and Shugart 1970)

VARIABLE	DESCRIPTION
<u>Vegetation Parameters</u>	
Shrub density	Belt transect; 'Reach Stick'
Canopy cover	Transect; ocular tube with cross-wire
Ground cover	Transect; ocular tube with cross-wire
Canopy height	Clinometer
Tallest tree height	Clinometer
Number of trees in seven DBH size classes (in cm)	15 m radius plot; 'Reach Stick', DBH size classes 15-29, 30-44, 45-59, 60-74, 75-89, 90- 104, >105.
<u>Nest-tree Parameters</u>	
Nest tree height	
Nest tree DBH	Clinometer
Height of first branch	Measuring Tape
Distance to large tree (≥ 60 cm DBH)	Clinometer Measuring tape or visual estimation
<u>Nest-cavity Parameters</u>	
Cavity height	
Diameter at nest height	Clinometer
Dimensions of cavity entrance	Measuring tape or visual estimation Measuring tape or visual estimation
Distance to nearest branch	
Cavity entrance shape	Clinometer Circular / Oval
Mode of cavity formation	At pre-existing primary cavity, or woodrot at broken-off branch
Cavity location	Branch / Tree trunk
Orientation of cavity	Magnetic Compass
Nest tree species	

Table 2: Proportion of nests and potential nest cavities of the Malabar Grey Hornbill in various tree species

S. No.	Tree Species	Family	Relative abundance of tree % N = 157	Nests % N=27
1	<i>Alseodaphne semecarpifolia</i>	LAURACEAE	9.6	25.9
2	<i>Hopea parviflora</i>	DIPTEROCARPACEAE	10.8	11.1
3	<i>Aglaia roxburghiana</i>	MELIACEAE	5.7	11.1
4	<i>Artocarpus sp.</i>	MORACEAE	-	11.1
5	<i>Mimusops elengi</i>	SAPOTACEAE	1.9	7.4
6	<i>Mesua ferrea</i>	CLUSIACEAE	1.3	3.7
7	<i>Ceiba pentandra</i>	BOMBACACEAE	-	3.7
8	<i>Lagerstroemia lanceolata</i>	LYTHRACEAE	-	3.7
9	<i>Eleodendron glaucum</i>	CELASTRACEAE	1.3	3.7
10	<i>Bischofia javanica</i>	EUPHORBIACEAE	1.9	3.7
11	<i>Dysoxylum sp.</i>	MELIACEAE	1.3	3.7
12	<i>Vitex altissima</i>	VERBENACEAE	3.8	3.7
13	<i>Pterospermum hynaena</i>	STERCULIACEAE	1.3	3.7
14	Others		61.2	-

Appendix 1

Plant and animal food delivered at the nest by the male Malabar Grey Hornbill.

Sugar-rich fruits

1. *Ficus* spp. (Moraceae)
2. *Mimusops elengi* (Sapotaceae)
3. *Bridelia* sp. (Euphorbiaceae)
4. *Elaeagnus conferta* (Elaeagnaceae)
5. *Linoceira intermedia* (Sapindaceae)
6. *Eugenia* sp. (Myrtaceae)
7. *Filicium dicepiens* (Oleaceae)
8. *Ziziphus* sp. (Rhamnaceae)
9. *Glycosmis pentaphylla* (Rutaceae)

Lipid-rich fruits

10. *Uvaria* sp. (Lauraceae)
11. *Neolitsea* sp. (Lauraceae)
12. *Cinnamomum* sp. (Lauraceae)
13. *Persea macarantha* (Lauraceae)
14. *Litsea* sp. (Lauraceae)
15. *Beilschmedia* sp. (Lauraceae)
16. *Myristica dactyloides* (Myristicaceae)
17. *Knema attenuata* (Myristicaceae)
18. *Polyalthia* sp. (Annonaceae)
19. *Strychnos nux-vomica* (Loganiaceae)*

NOTE: * - quality of the fruit not known

Vertebrates

1. Fledgling
2. Snake
3. Calotes
4. Gecko
5. Frog

Invertebrates

1. Beetles
2. Cricket
3. Grass/leafhoppers
4. Cicada
5. Stick insect
6. Caterpillars
7. Wasps/winged termites
8. Millipede/centipede/worms
9. Scorpions

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